A study of Silicon sensor for ILD ECAL

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- Motivation of this study
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  - Capacitance
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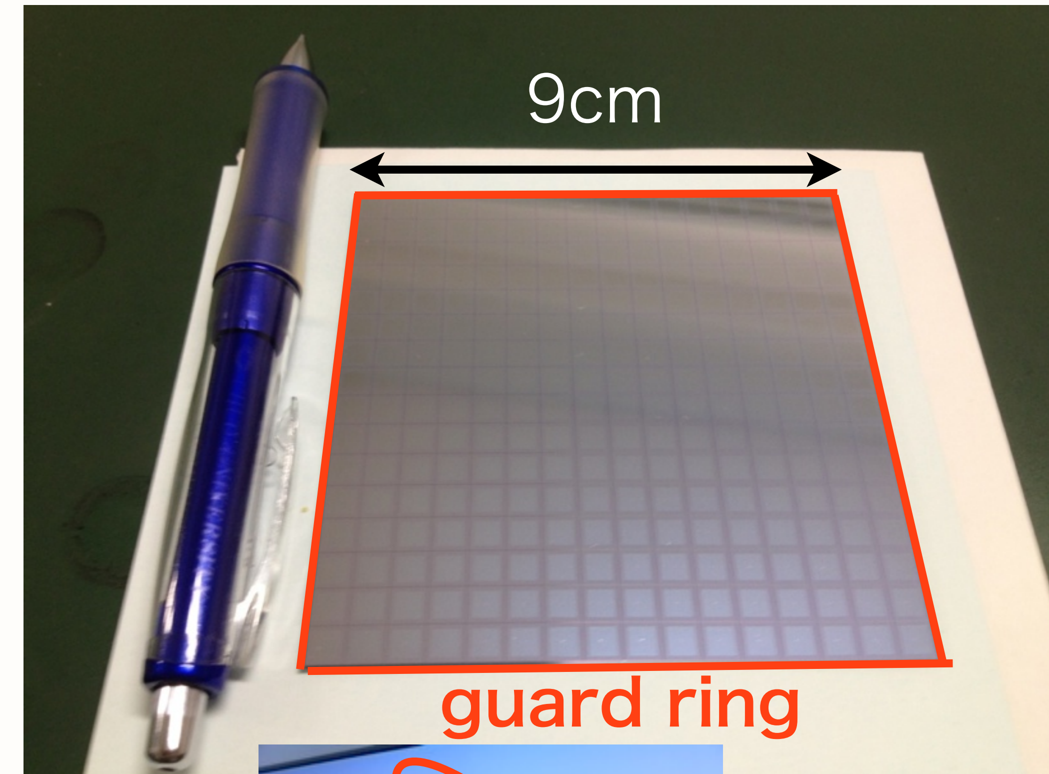
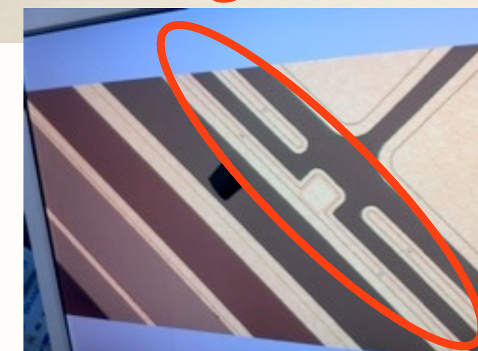
- Summary

Si sensor for ILD ECAL

- Produced by HPK
- 1pixel = 5.5mm x 5.5mm
- 16 x 16 = 256 pixels
- Thickness : 320 μm
- Guard ring width is...
  80μm(1GR),20μm(2,4-GR)

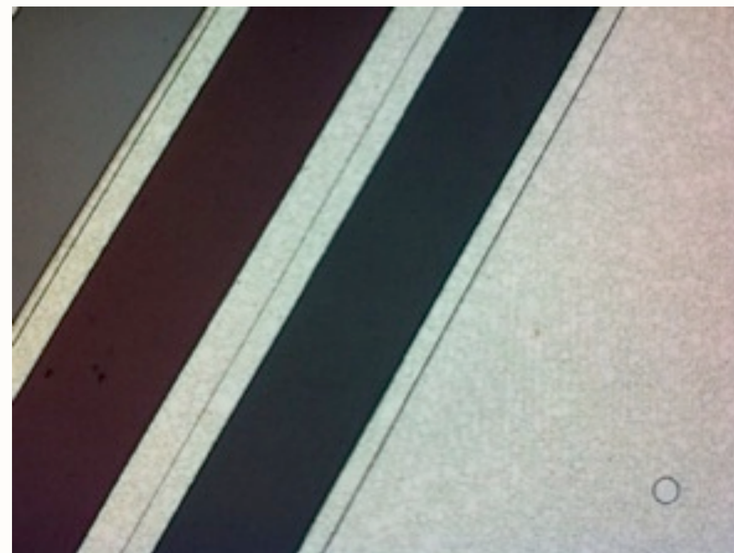




2-split GR

4-split GR

w/ guard ring

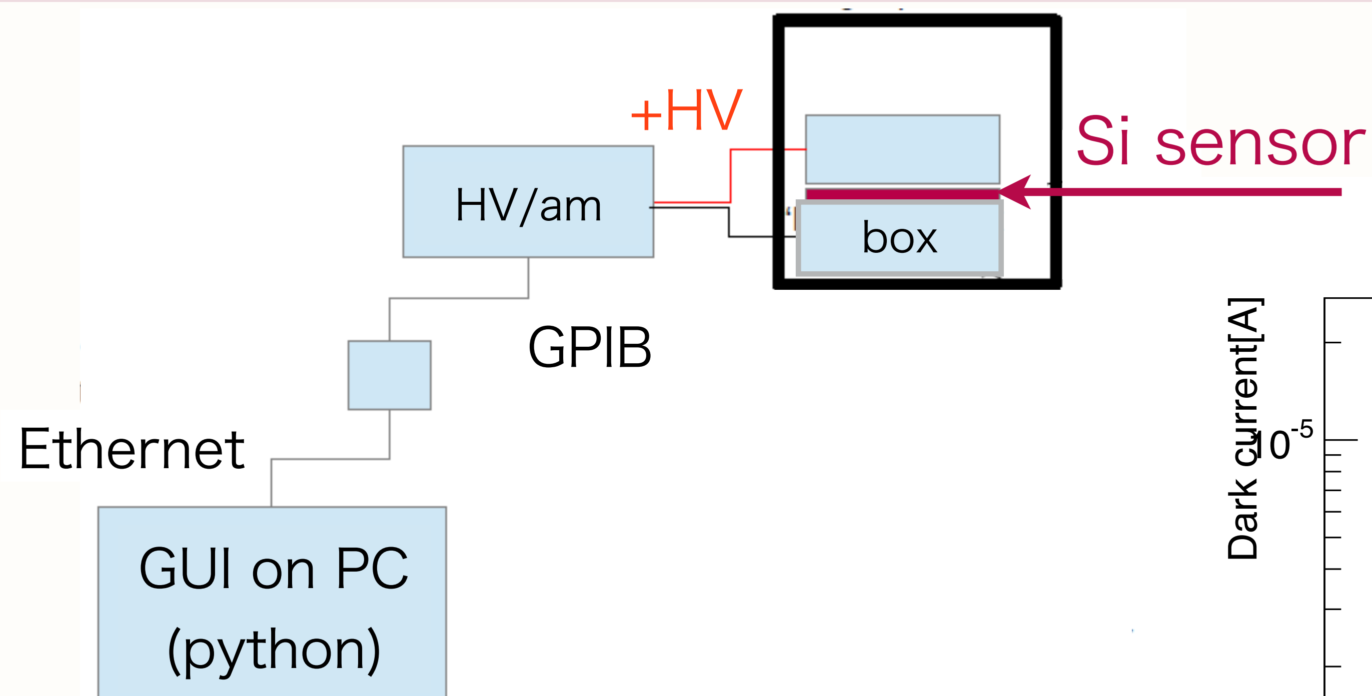


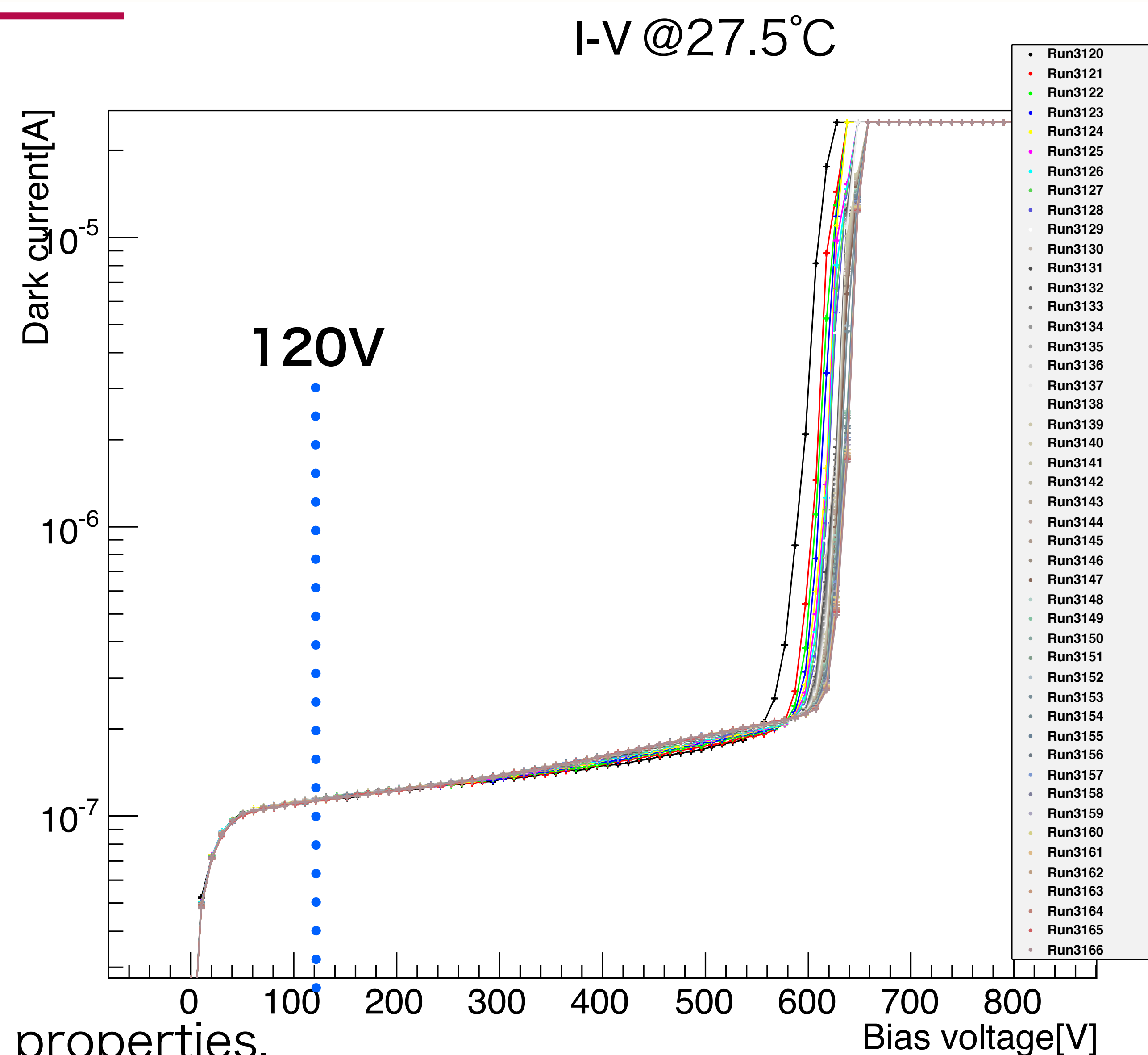
w/o guard ring

Motivation

- Measuring properties
  - To understand Si sensor properties, it is necessary to develop Si sensor testing station for quality control.
- Response to the laser
  - can investigate what will happen when particle comes into Si sensor.
  - We need to understand effects of gaps/guard rings to improve Si ECAL performance.
  - If we can investigate GR effect in laboratory, it is very convenient and fast.
  - Using laser, we can limit the region where electrons and holes generation.

Leakage current



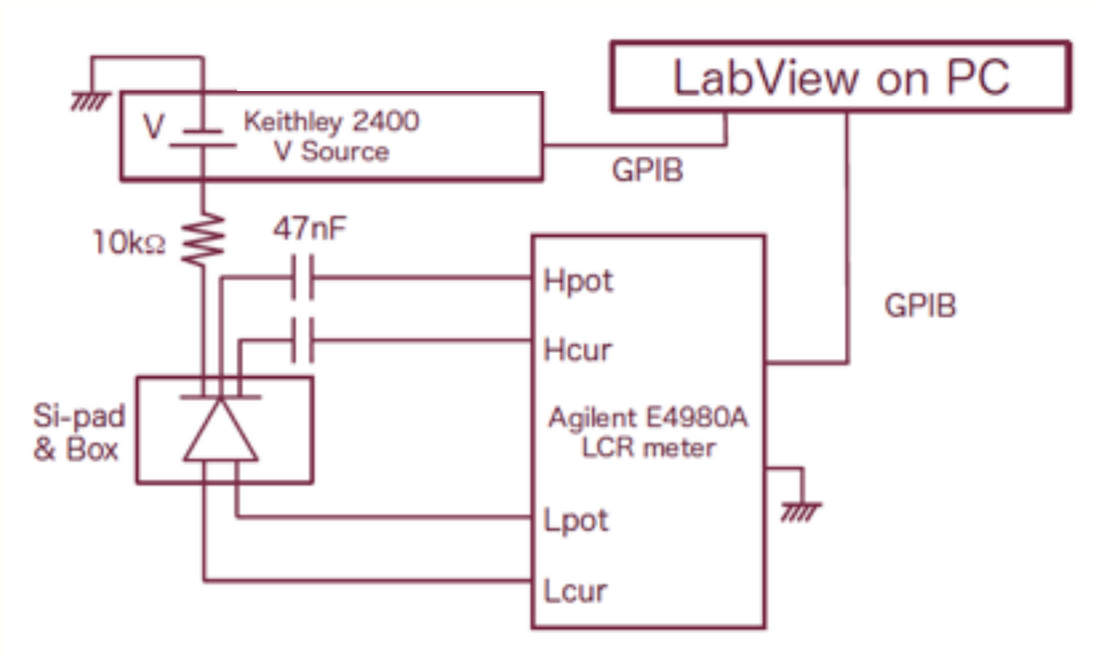


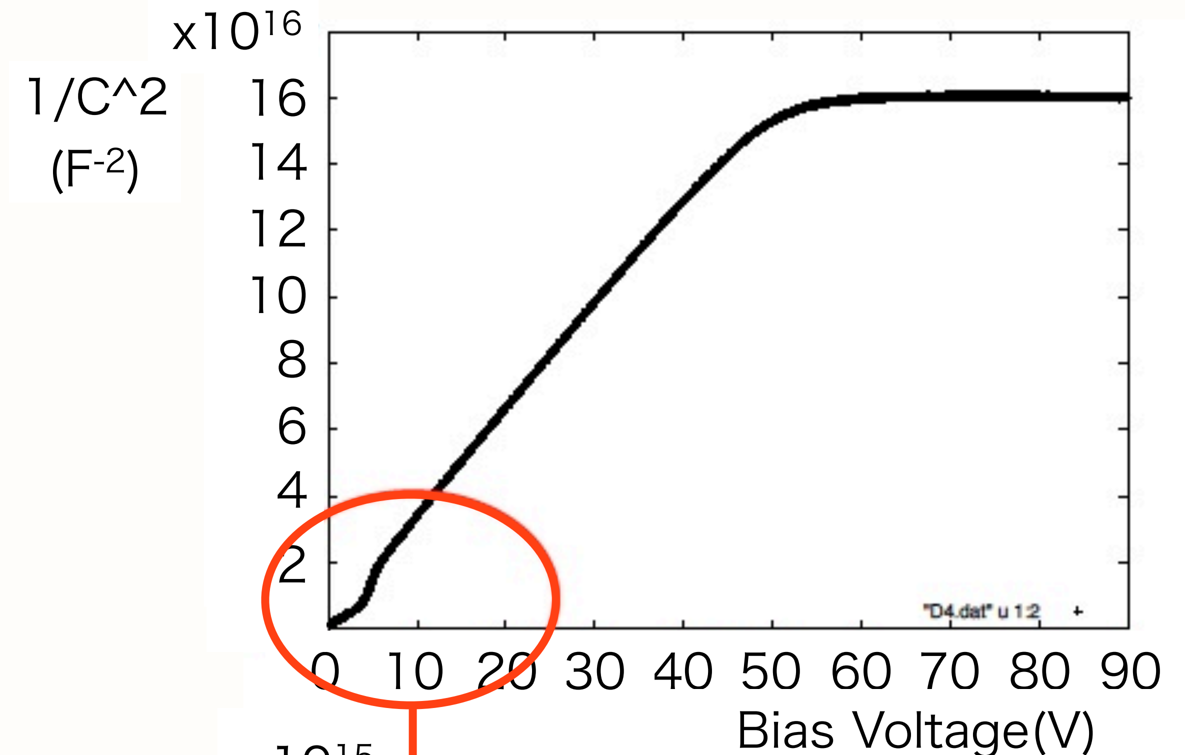
Dark current around 120V (operation V)
is stable (flat) and low(a few hundred nA).

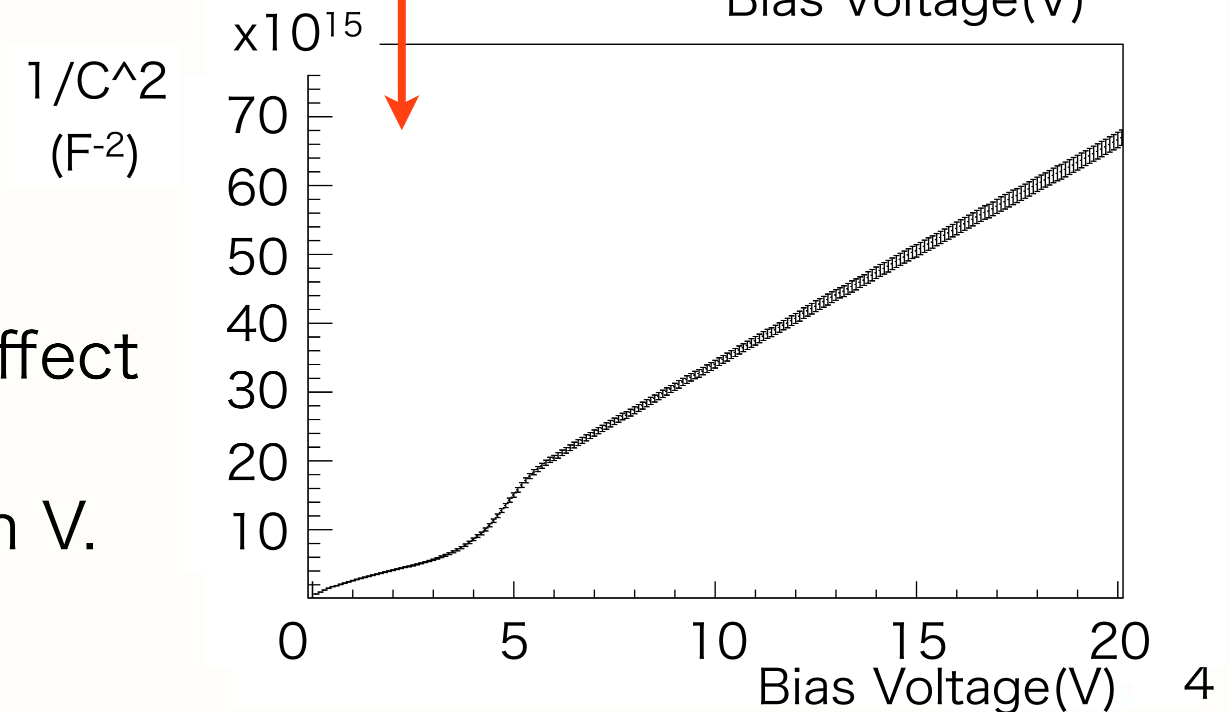
until 4 or 5 times measurements,
break down voltage went higher by each step

Good chip should have these (flat and low leak) properties.
We can compare this result with the other chips.

Capacitance







1/C^2 has very good linearity.

> 50V : saturated (full depletion)

< 6V : Metal Oxide Semiconductor (MOS) effect

Chip can be fully depleted before operation V.

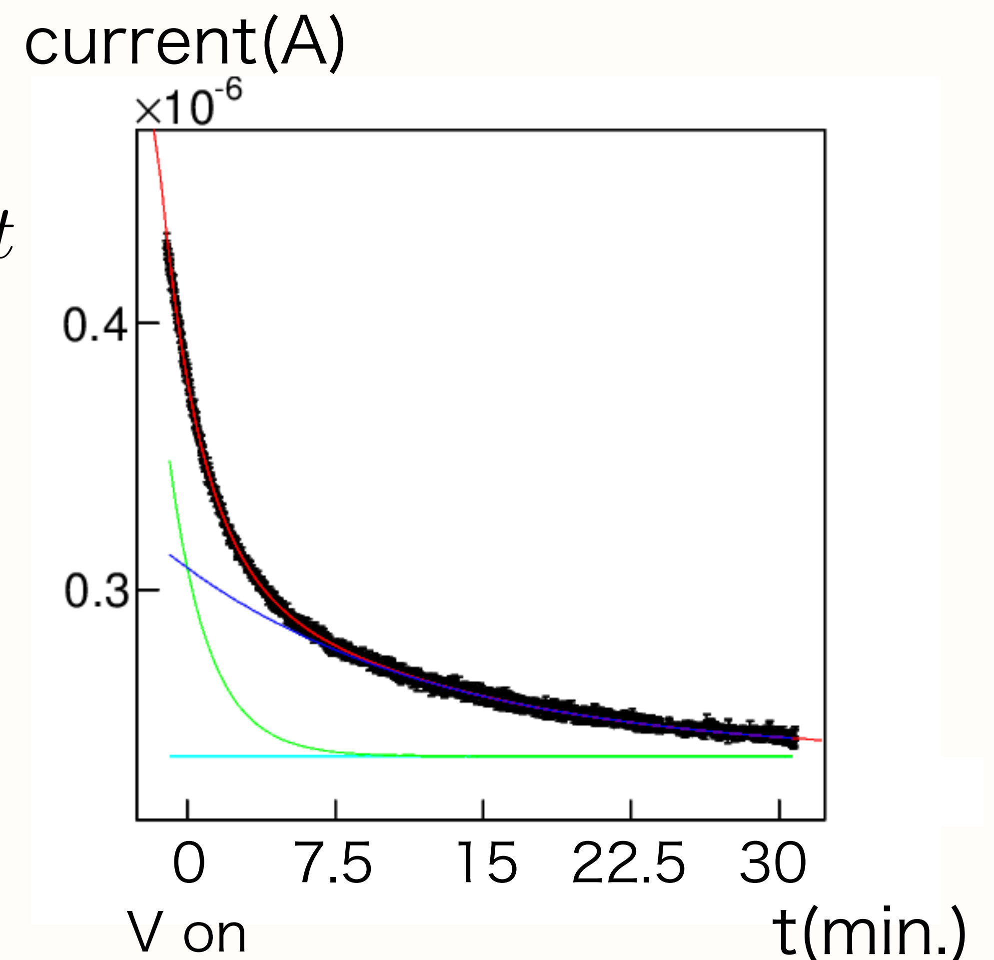
Time characteristics

Time characteristics mean the time to stabilize leakage current.
When one turn on the HV on chip, one should wait certain time.

There are two time components.

$$I = A\exp(-t/\tau_1) + B\exp(-t/\tau_2) + const$$

	fast component(τ_1)	slow component(τ_2)
generation time @ 250V	40 s	600 s



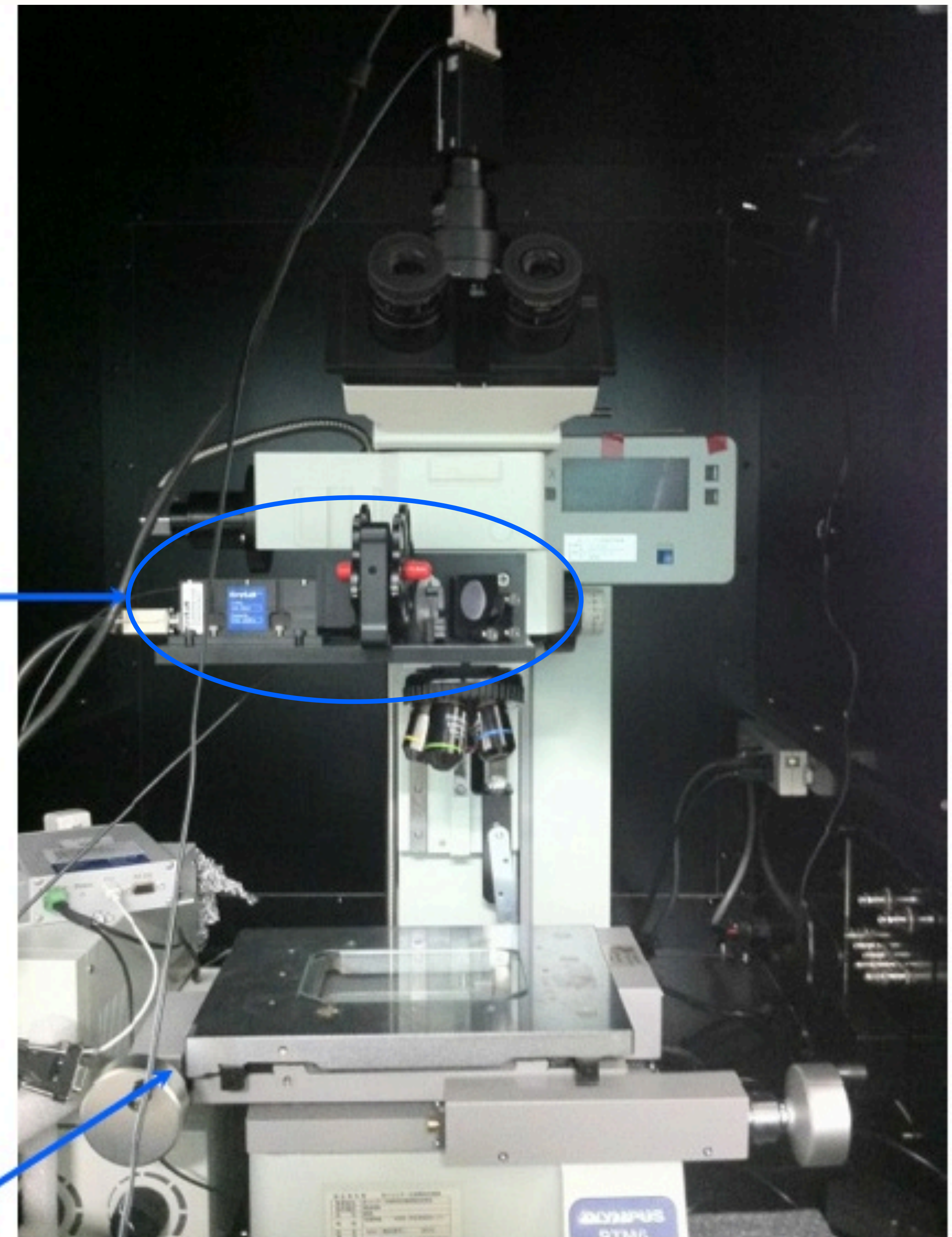
Laser system

CRYLAS GmbH
DSS1064-Q2 (Class 3B)
Wave length : 1064 nm
Pulse width : ~ 1.5 ns
Pulse energy : > 20 μJ/pulse
~ 10^{14} photons/pulse
Peak power : > 13kW
Reputation rate : 1 ~ 10kHz

Interface of the control software

Laser
Trigger
ND-filters
mirror

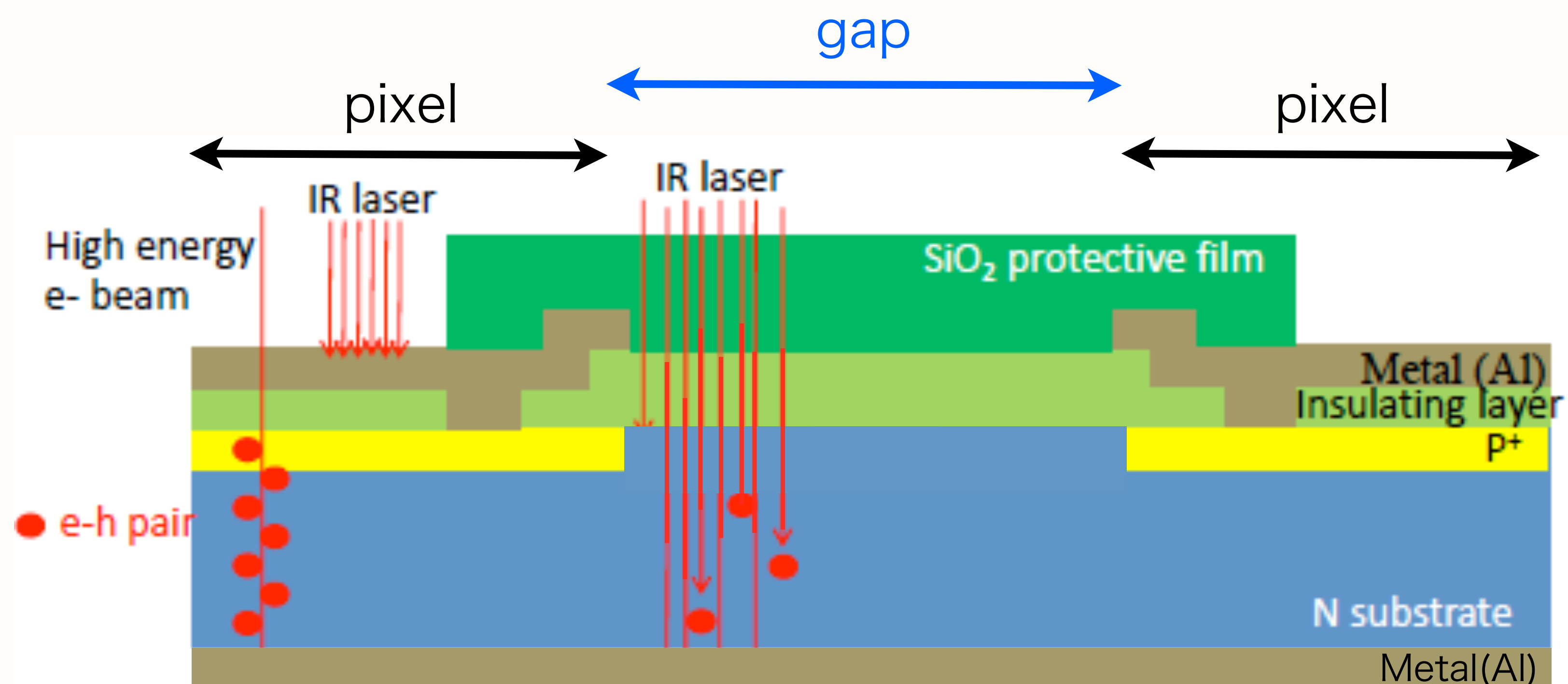
x-y stage



Infrared laser

- wave length -> 1064 nm = 1.16 eV
  band gap energy of Si = 1.12 eV

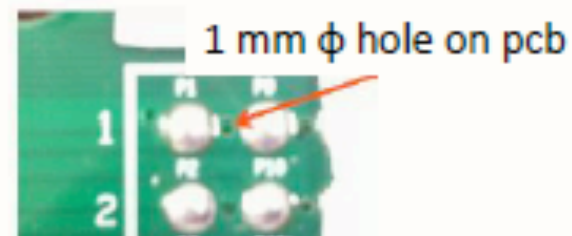
- We want to know GR and gap effect,
  we inject the laser to Si gap.
  (between. pix. and pix. or pix. and guard ring)

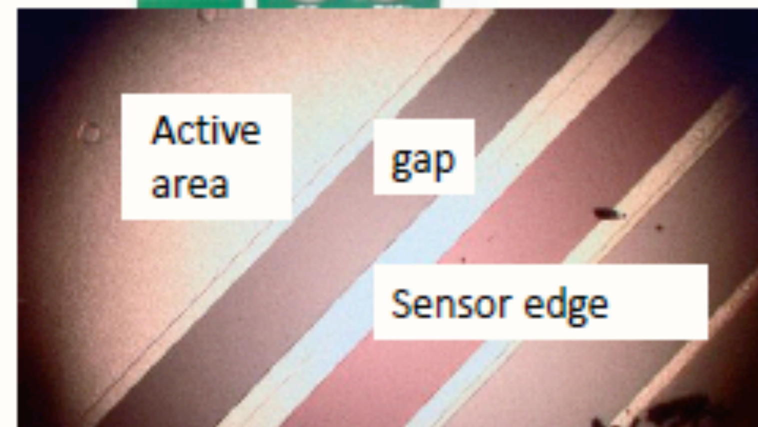


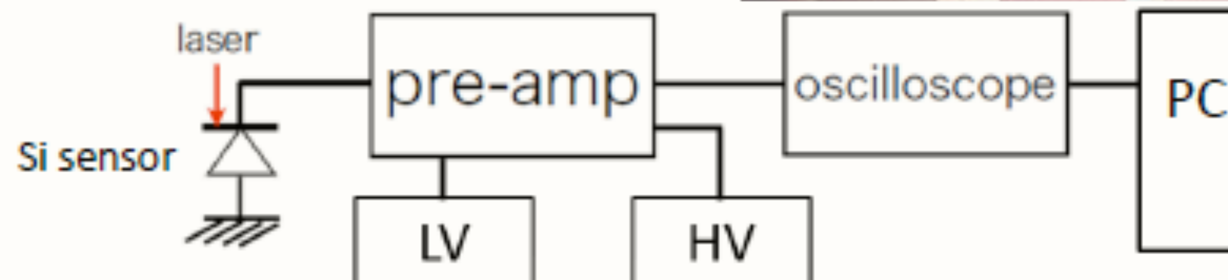
Setup

- Laser diameter at the focus point is less than 23μm.
- The difference size between pixel and guard ring is ~39μm. This size is enough small to put the laser into it.

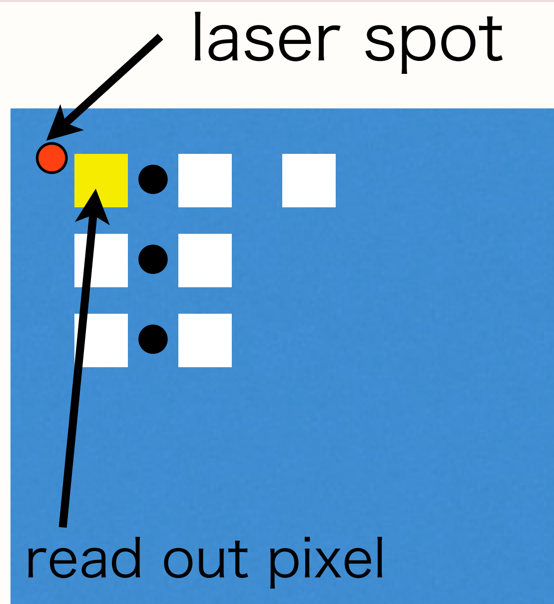
To expose Si to the laser directly, we make a 1mm hole on PCB.



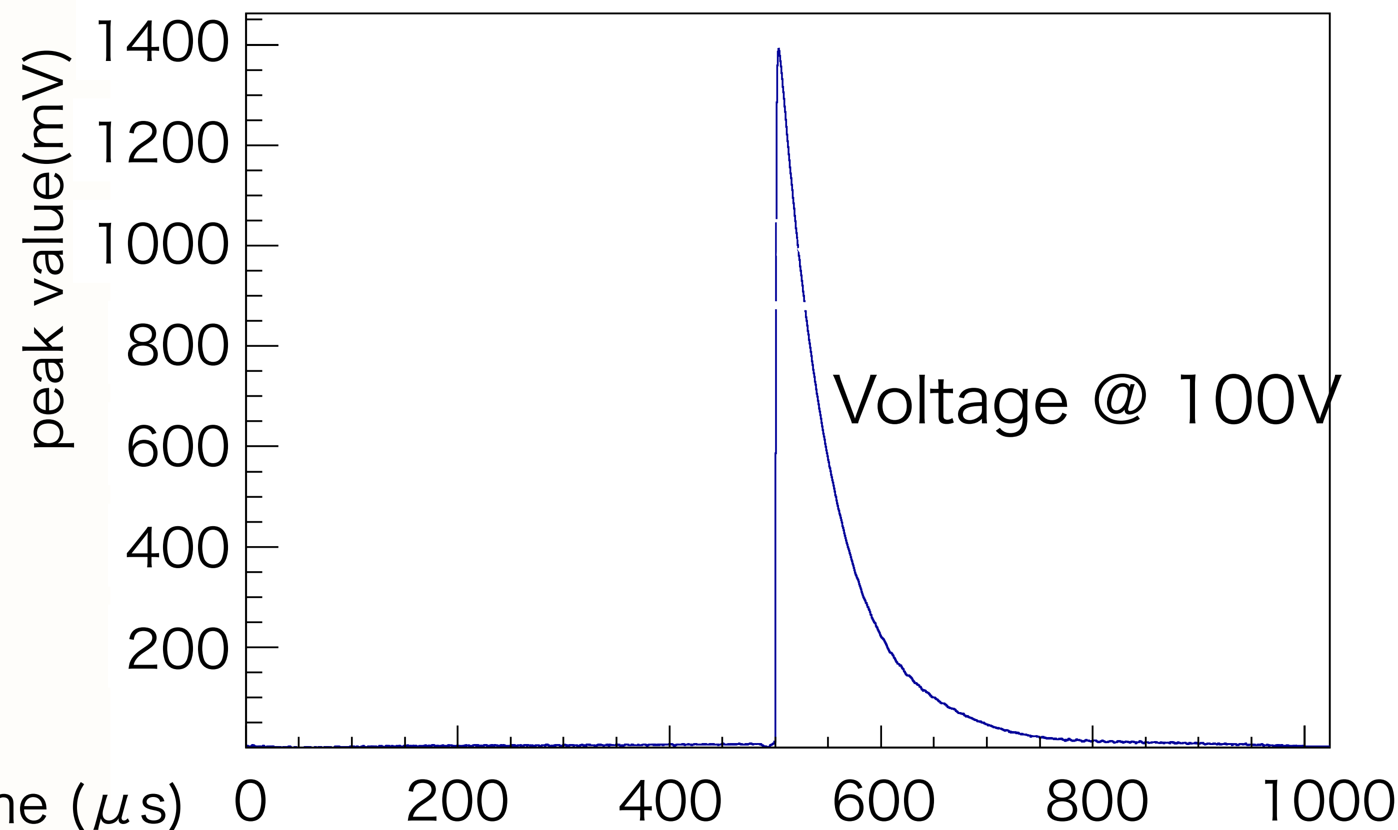


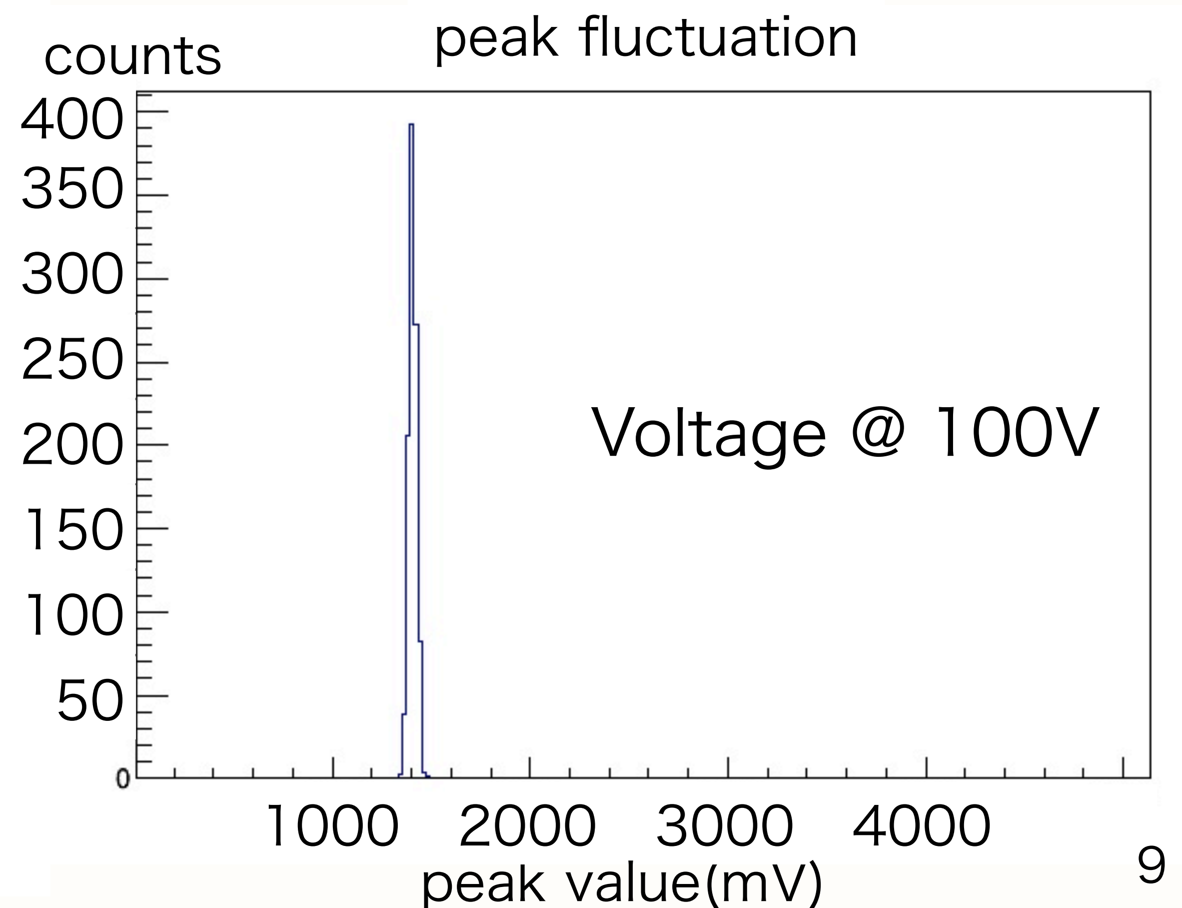


Response to the laser



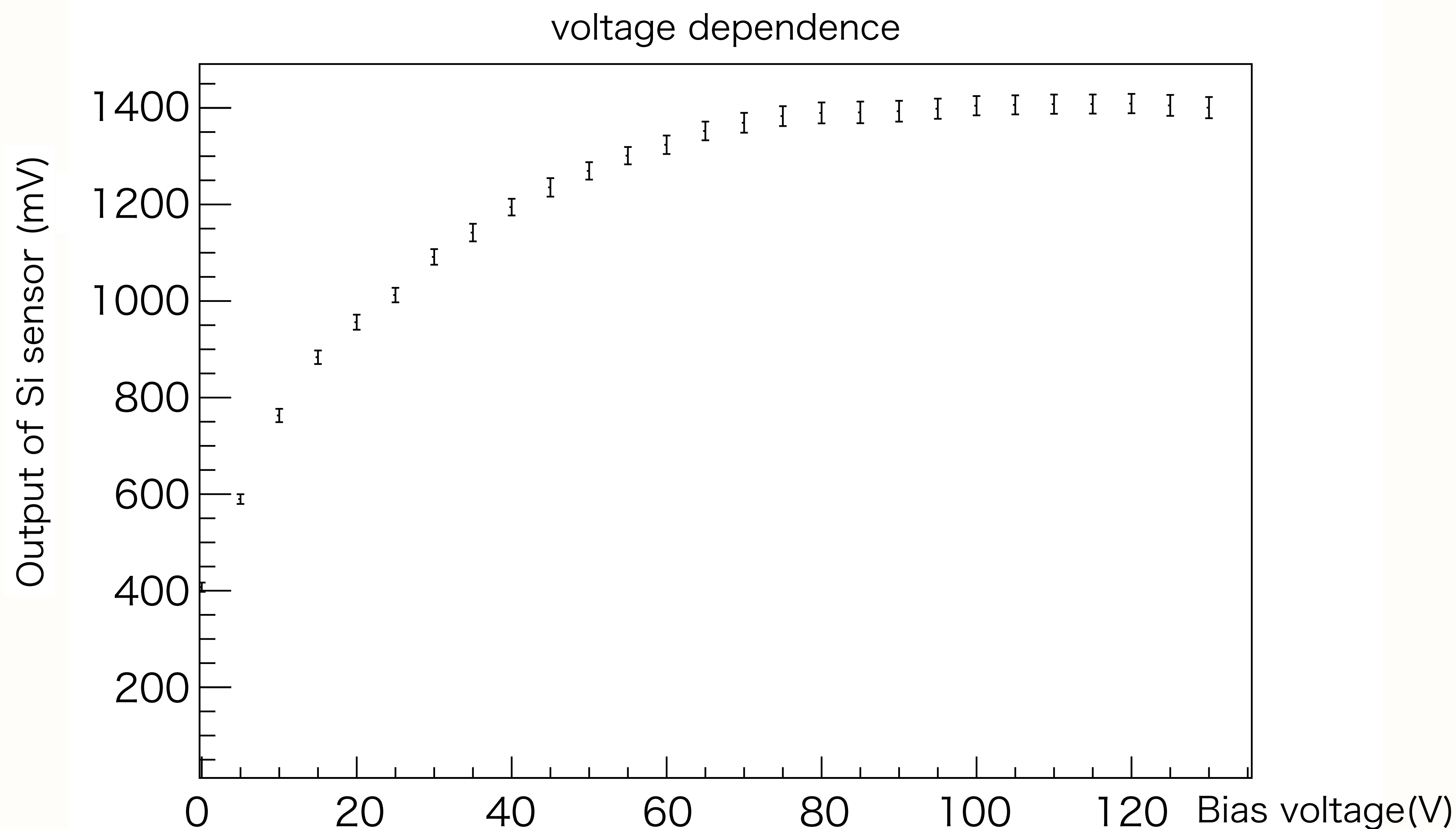
- First, we measured the laser signal using oscilloscope.
- fluctuation of peak value ~3%





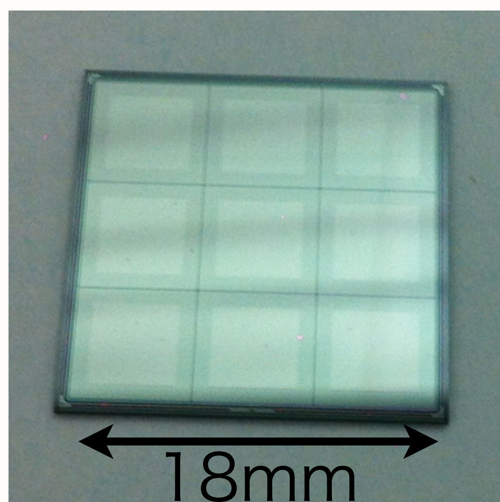
Voltage dependence

Saturation occurred at full depletion voltage.
This result almost corresponds to 1/C^2 result.
(1/C^2 : 50V, laser : 80V, this gap is under investigation)

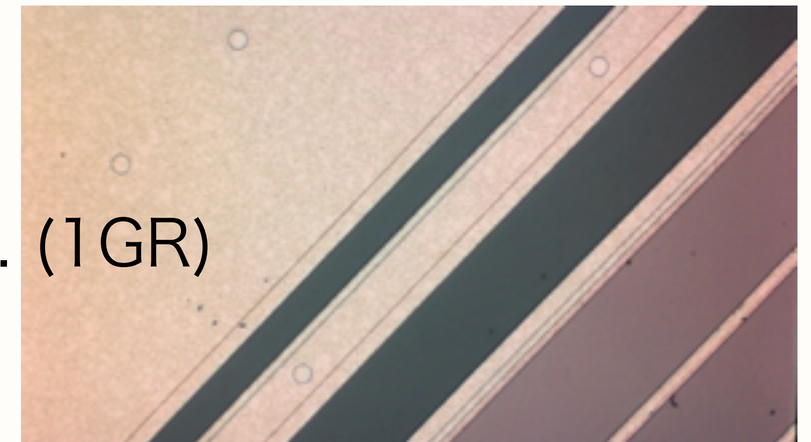


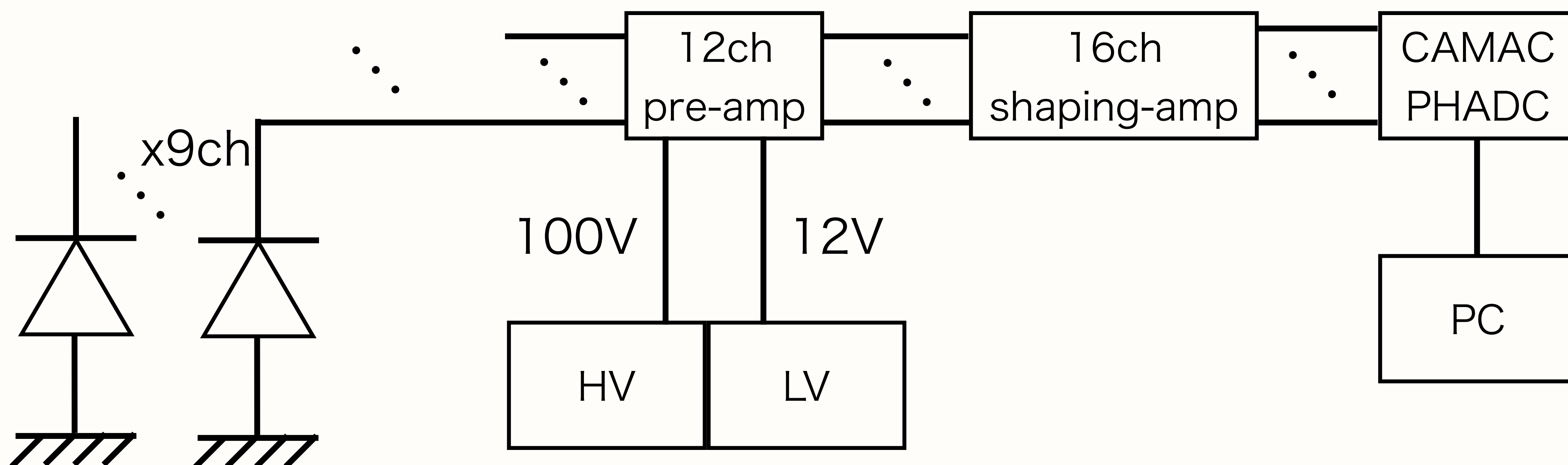
Setup for multi read out

To do multi read out, we changed our read out system slightly.
We use baby chip during multi read out measurement.

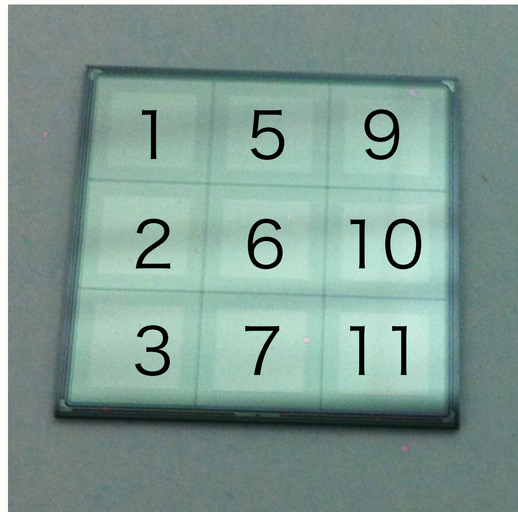


baby chip has 3x3 = 9 pixels
guard ring is same as main chip. (1GR)



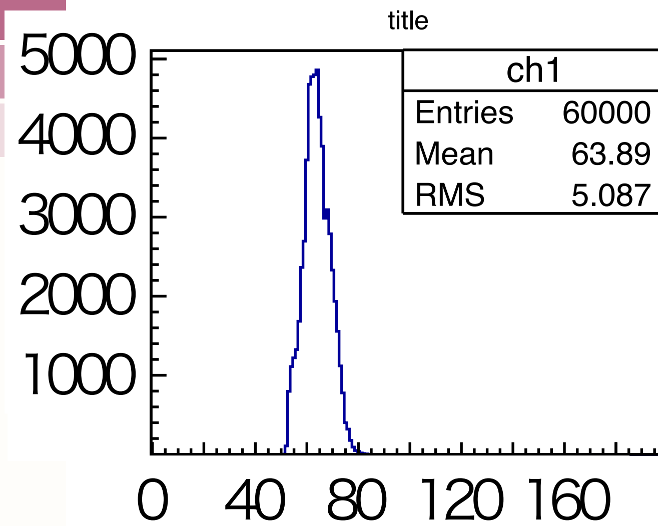


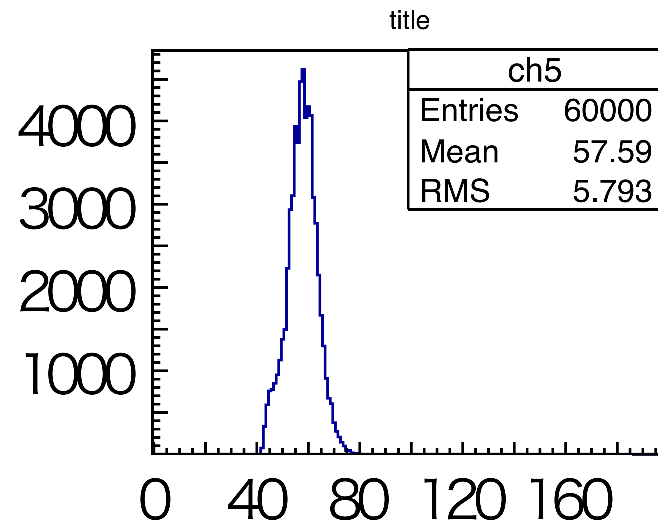
Multi pixel read out

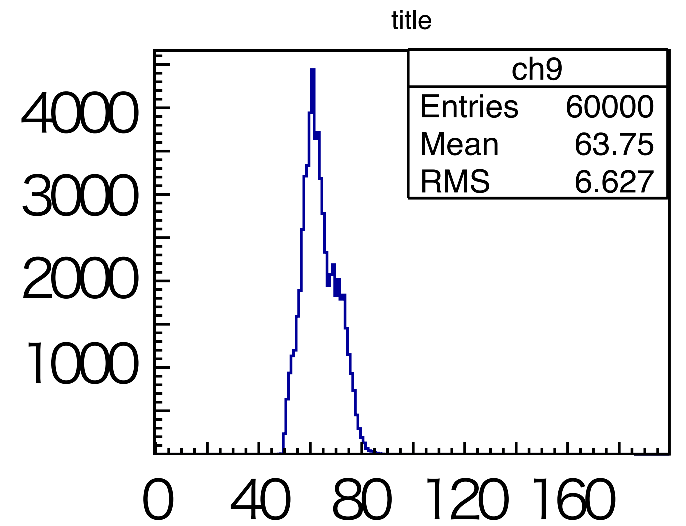


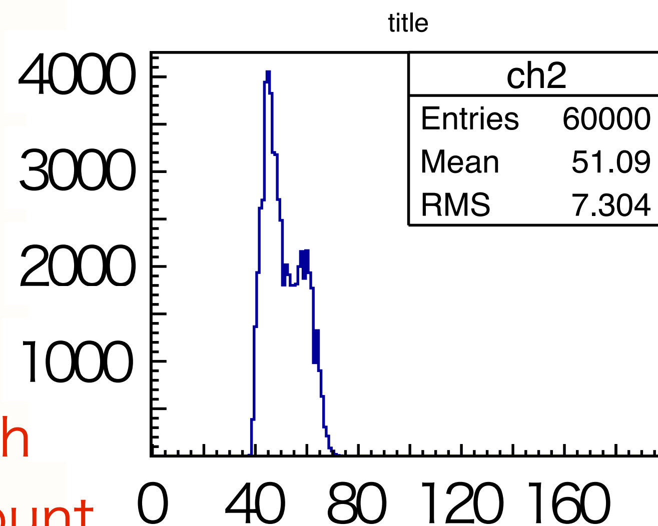
baby chip
3 x 3 = 9 pix.

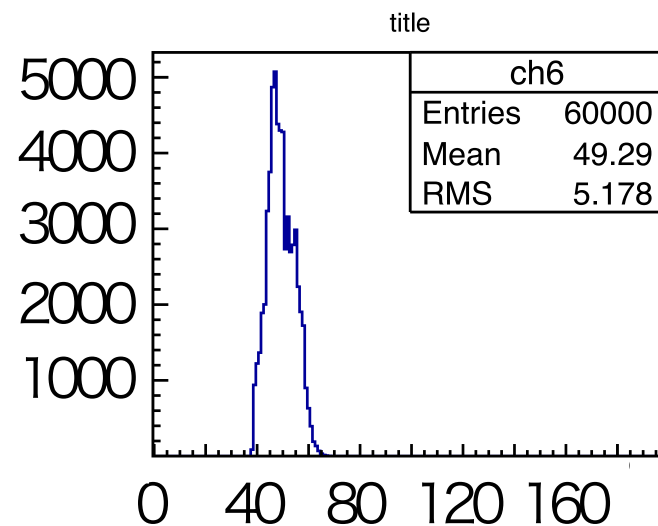
pedestal :40-80 ADC ch
horizontal axis :ADC count
vertical axis :counts
@ 100V

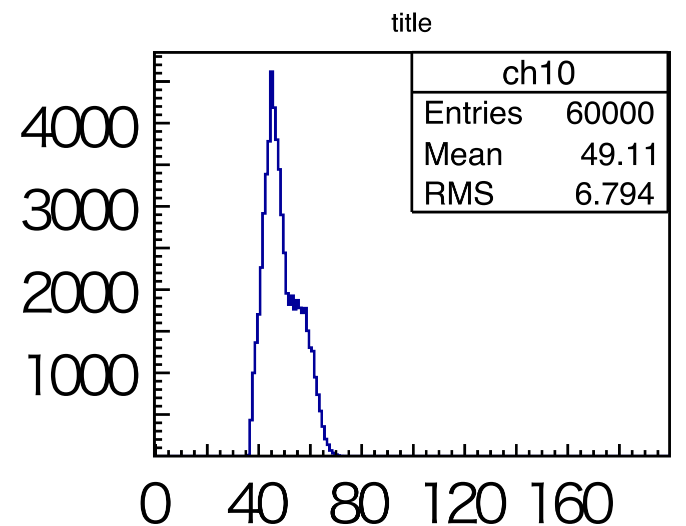


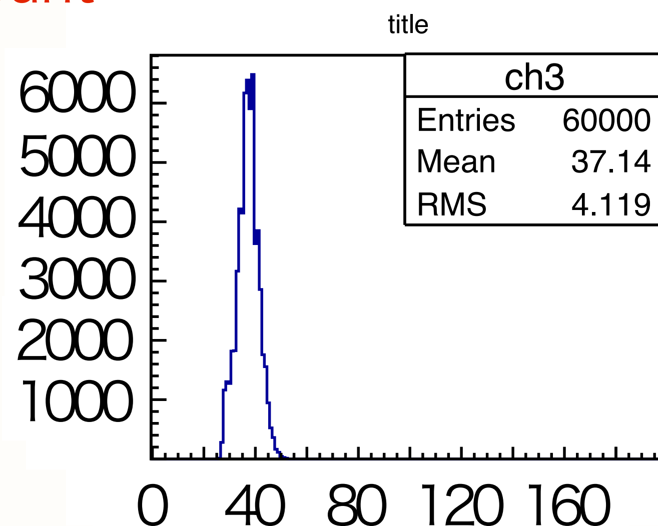


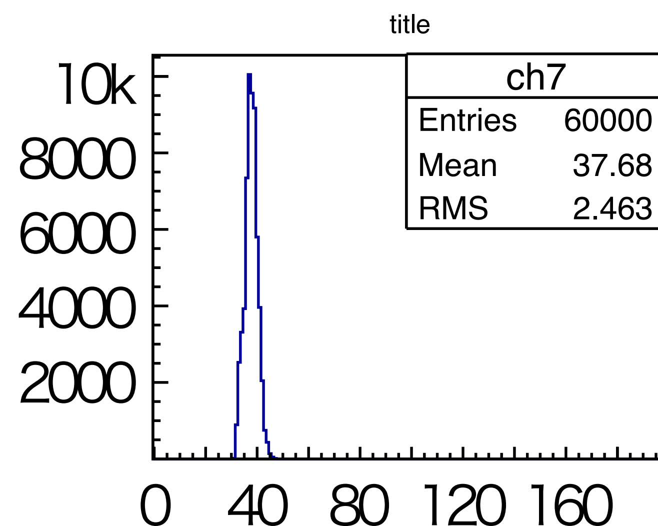


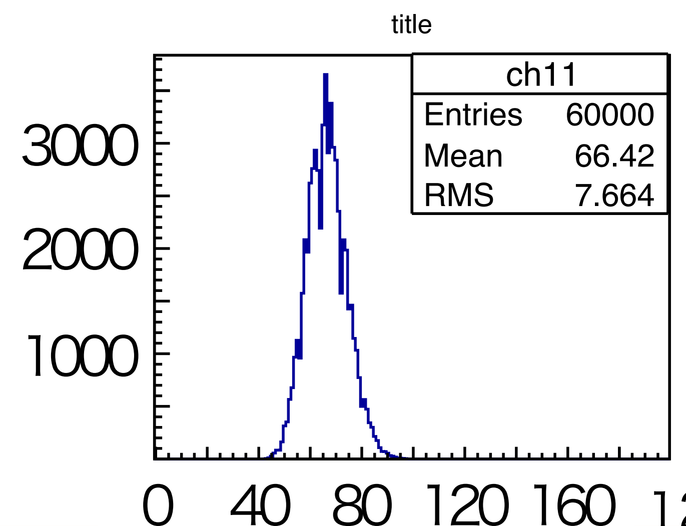




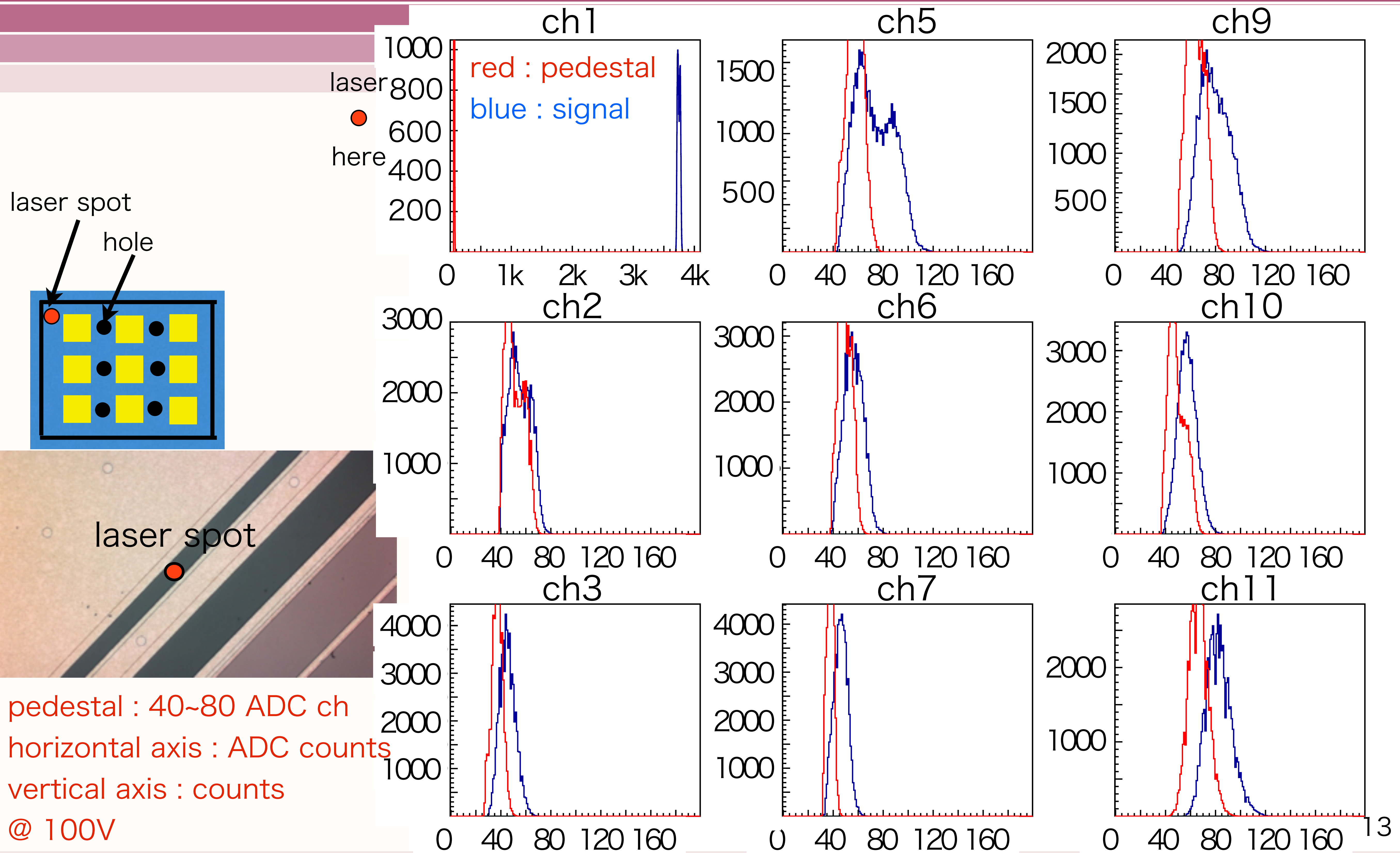








Multi pixel read out (Cont.)



pedestal : 40~80 ADC ch
horizontal axis : ADC counts
vertical axis : counts
@ 100V

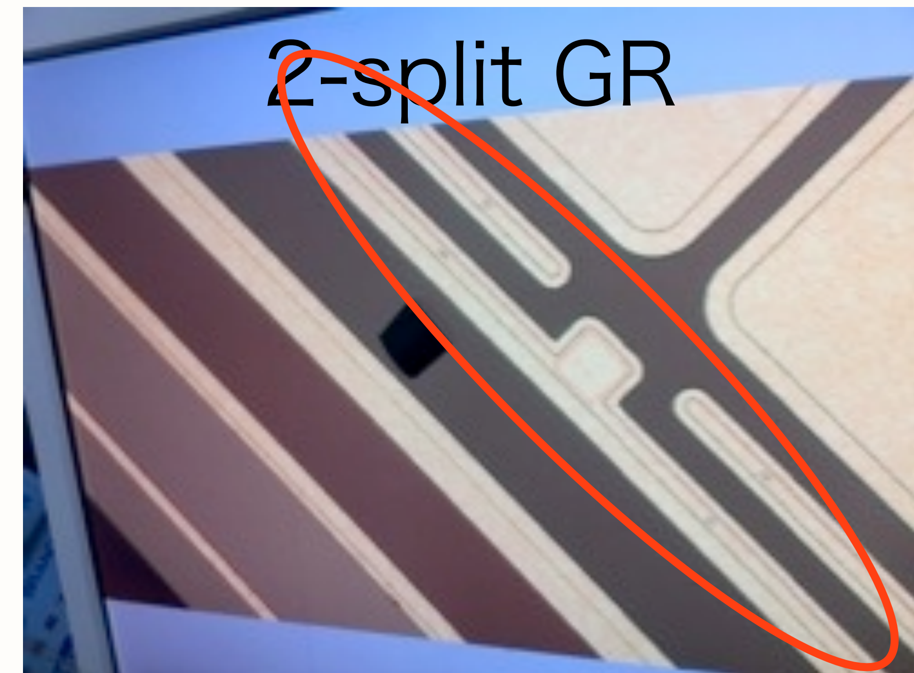
Summary & Prospect

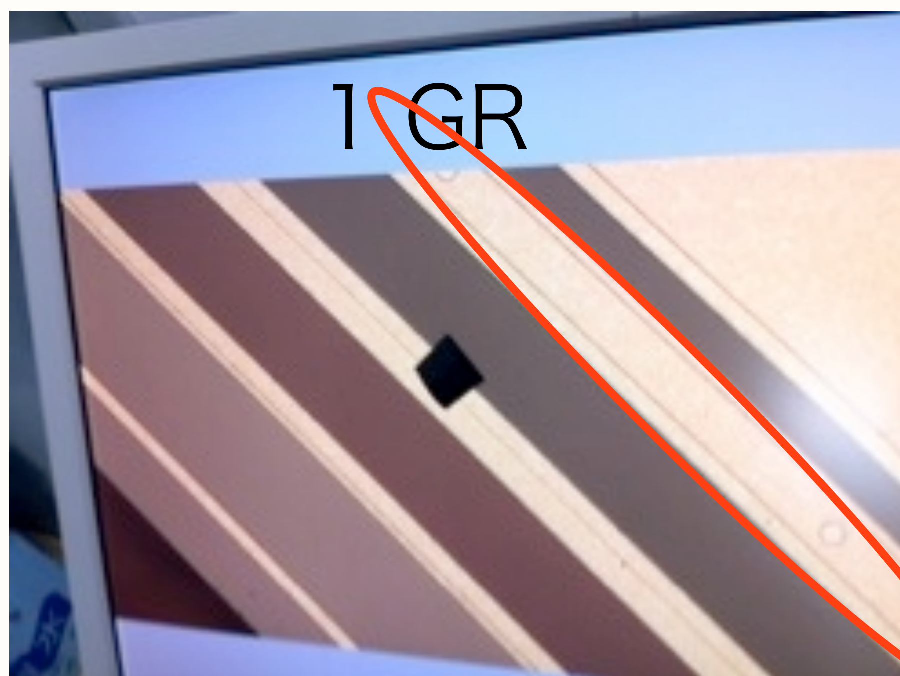
- We established the Si chip test-bench system both in Tokyo and Kyushu.
  - leakage current and capacitance (@Both)
  - radiation test and time characteristics (@Tokyo)
  - guard ring and cross talk (@Kyushu)
- We are now ready to start measurement for quality control.
- Radiation test is now preparing.
- We installed a laser system in Kyushu University, and now we can read out multi pixel, next step is investigation of GR effect.
(1GR, no GR, 2-split GR, 4-split GR)
(We need to upgrade our laser system)

Thank you for listening!!

back up slides

type of guard ring





recombination time

Recombination time is calculated from constants A, B.

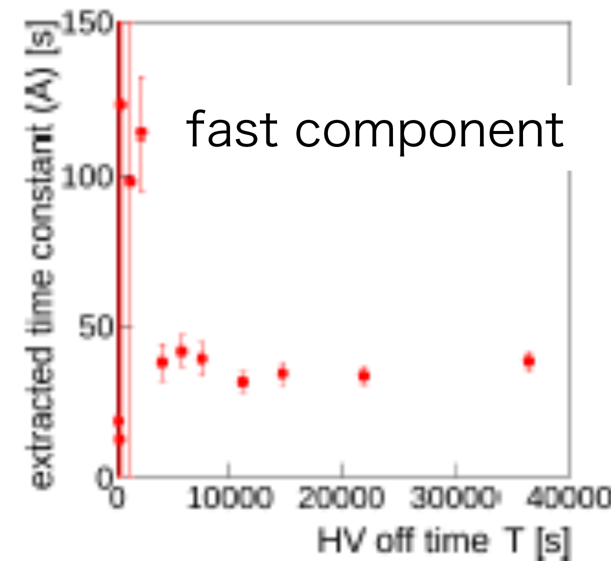
$$A = C_A(1 - \exp(-T/\tau_T))$$

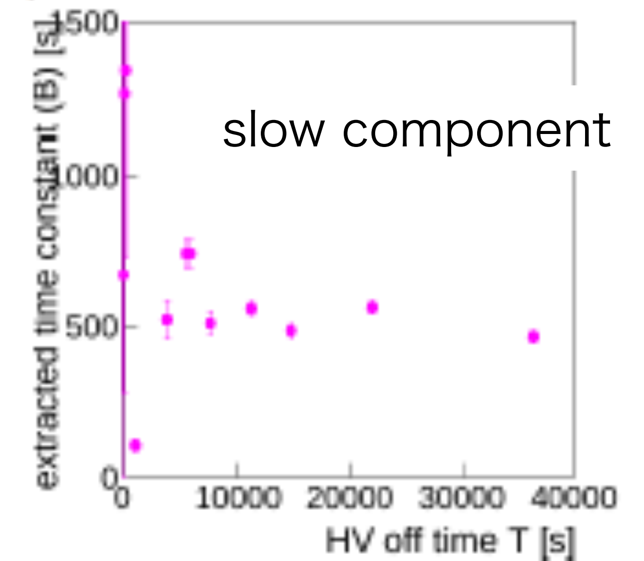
C_A showed A at infinity region.

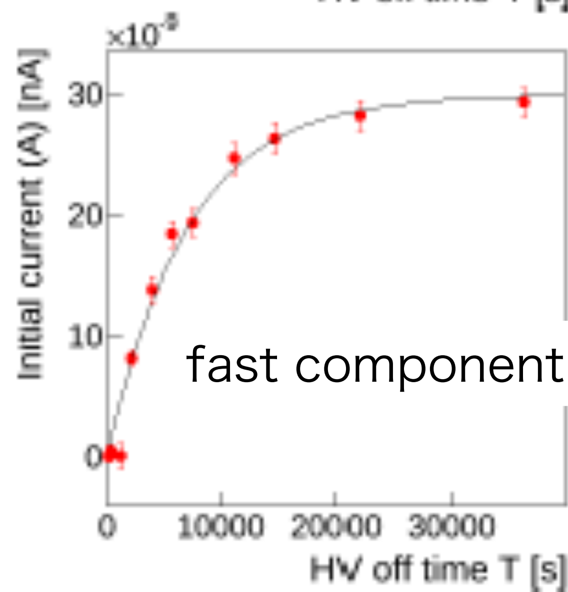
fitted by...

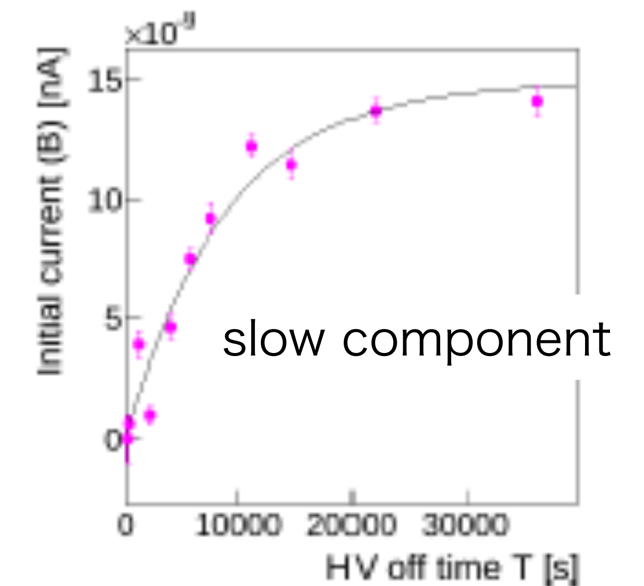
$$I = A\exp(-t/\tau_1) + B\exp(-t/\tau_2) + const$$

	fast component(τ_1)	slow component(τ_2)
generation time @ 250V	40 s	600 s
recombination te @ 0V	7000 s	9000 s

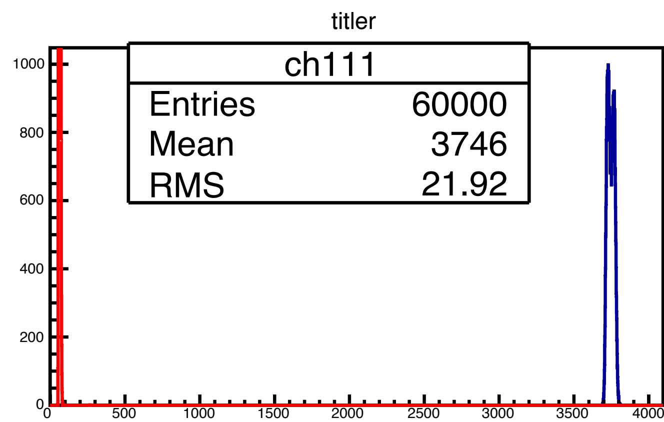


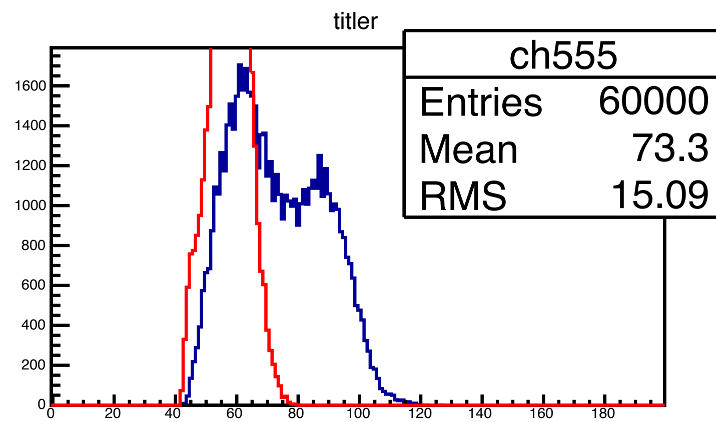


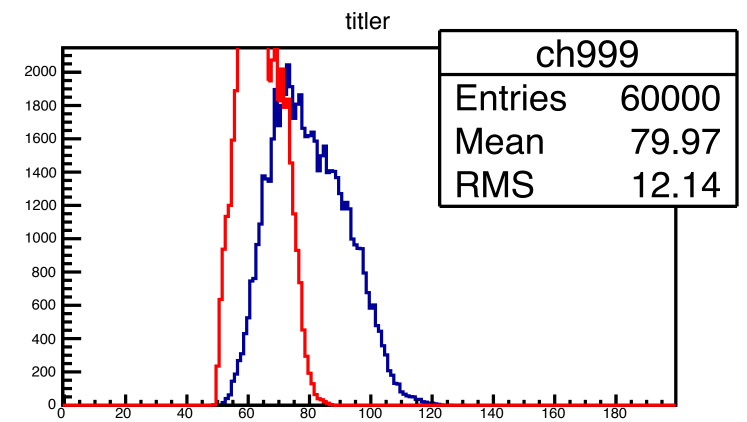


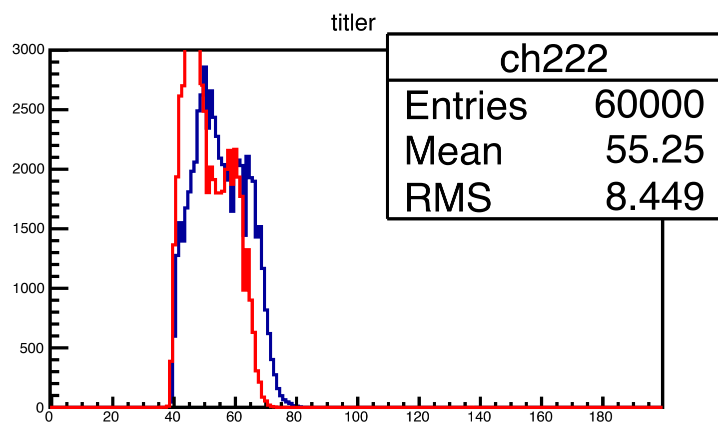


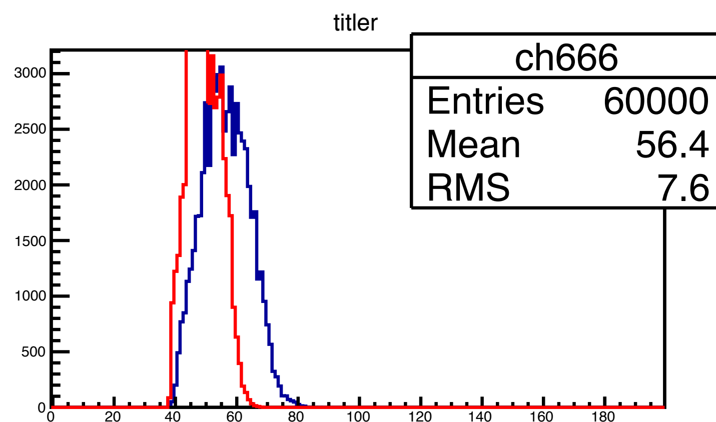
pedestal+gr

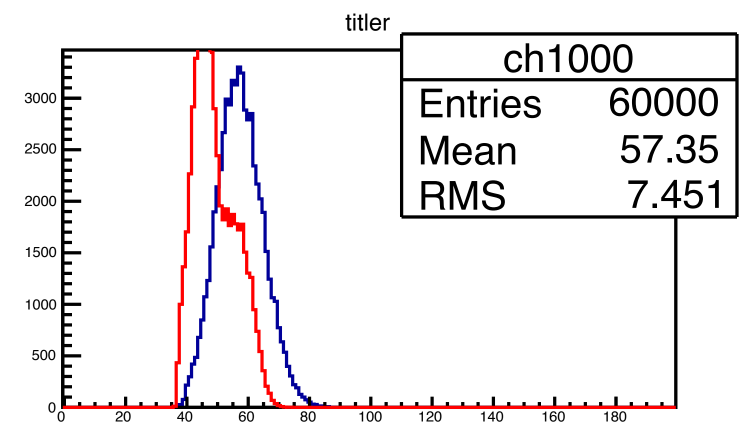


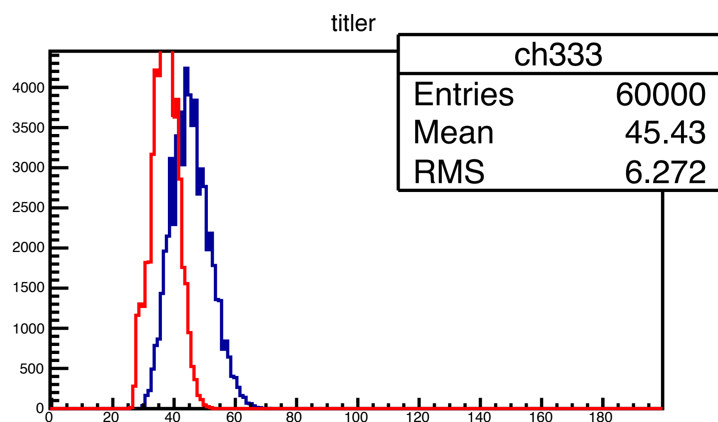


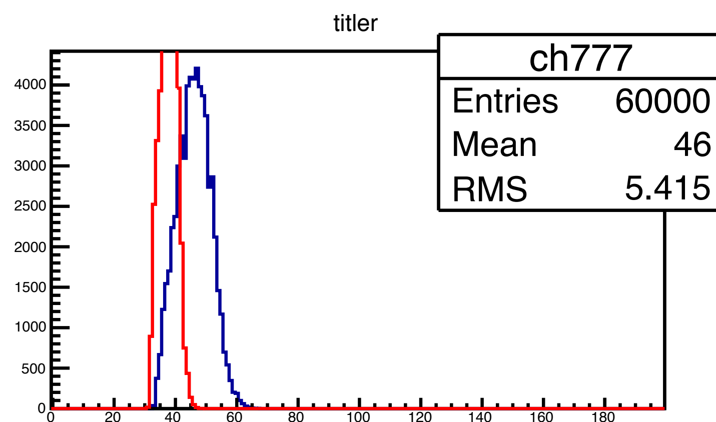


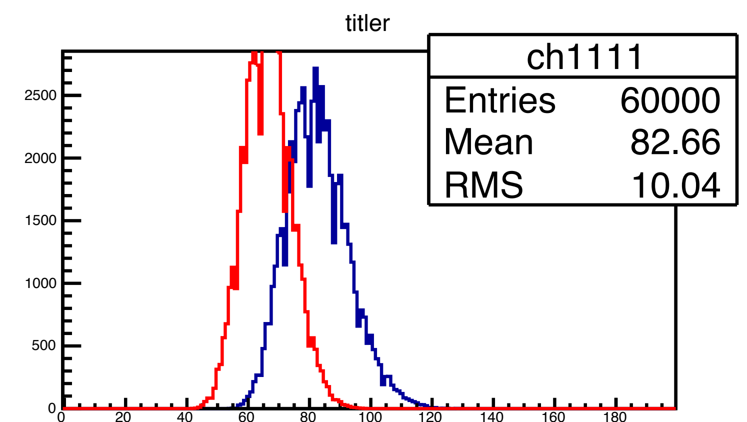












ngr+gr